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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01N 29/14 — A1

(11) International Publication Number: WO 96/22526

(43) International Publication Date: 25 July 1996 (25.07.96)

(21) International Application Number: PCT/US95/04688

(22) International Filing Date: 17 April 1995 (17.04.95)

(30) Priority Data:
08/374,481 17 January 1995 (17.01.95) US

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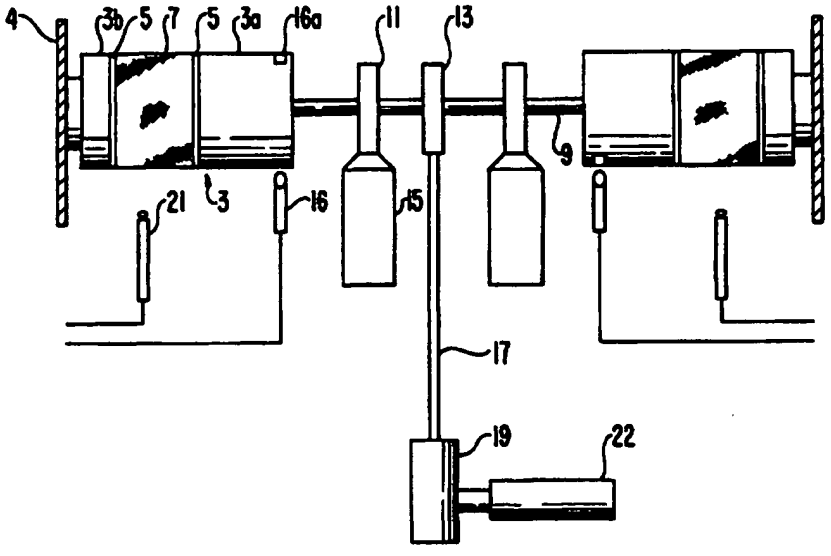
(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: ACOUSTICAL APPARATUS FOR TESTING NOISE GENERATED BY FABRICS AND METHOD FOR TESTING



(57) Abstract

An acoustical apparatus and assembly for testing noise generated by fabrics. The apparatus includes a revolving holding means (3a) and a stationary holding means (3b) to which a test sample of fabric (7) is attached. One test involves twisting the fabric first in one direction and then in another to generate a crumpling sound. A second test involves revolving the fabric 360° on a revolving holding means around a shaft while in contact with a draped fabric to generate a swishing sound. Sounds are measured with noise detection devices. Test procedures are also provided.

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TITLE OF THE INVENTION

ACOUSTICAL APPARATUS FOR TESTING NOISE GENERATED BY FABRICS AND METHOD FOR TESTING

FIELD OF THE INVENTION

This invention relates to acoustical apparatus and assembly for testing noise generated by fabrics. A testing procedure is also provided.

BACKGROUND OF THE INVENTION

With the development of new types of fabrics made from synthetic materials for integration into garments such as jackets, parkas, pants and other types of outerwear, a new assortment of features have also evolved. Most of these features are highly desirable such as the development of waterproof, windproof, and breathable materials such as laminates made from thin membranes of for example, expanded polytetrafluoroethylene commercially available from W. L. Gore & Associates, Inc., of Elkton, MD under the trademark GORE-TEX® Fabric. Many tests and apparatus have been developed to test these features.

With the employment of these fabrics into garments for different end uses, new characteristics have become important. One such characteristic involves the quietness of the fabric of the garment when worn. Often, when the wearer moves within a garment, the fabric either flexes or rubs against another fabric (whether the other fabric be of the same material or different). These movements generate different types of sounds or noises. The first type of noise relates to a crumpling sound which is generated when a fabric flexes. This type of noise is made up of frequencies across the entire audible spectrum (i.e. 0 - 20,000 Hz). Another type of noise under study relates to a swishing sound which is generated when the fabric rubs against a second fabric. This second fabric may be the same material as the first or may be a different fabric. Heretofore, no effort has been made to reproducibly quantify any of these noises generated from a fabric.

It is important that the sounds generated by these different movements be quantified so that an effort can be made to select materials that minimize those sounds.

This is particularly important for hunters where it is essential for the environment to be as quiet as possible. Typically a human is capable of hearing sounds occurring between 1500-5000 Hz, with the ear being most sensitive to noises occurring at 3500 Hz. Other mammals including for example deer and dogs are extremely sensitive to noises and are capable of hearing up to 20,000 Hz.

To date, there have been no standardized tests or apparatus developed to test such a phenomenon generated by fabrics. An assortment of sound level meters that test noise generated at different frequencies are commercially available however to date, there has been no development of tests or apparatus that employs conventional meters to measure noise generated in fabrics.

There is a need for a test apparatus to measure the noise generated by fabrics reproducibly.

SUMMARY OF THE INVENTION

An acoustical apparatus is provided to measure noise generated by fabric. The apparatus comprises at least one sound insulated chamber that contains a holding means, a sample of fabric, and a noise detection device to measure the noise or sounds generated by the fabric as it undergoes a series of motions. The apparatus also includes a revolving shaft connected to the holding means which causes the holding means to revolve about its longitudinal or horizontal axis, and means to revolve the shaft and cause the sample fabric to undergo a series of motions. Preferably, the apparatus comprises two chambers and two test meters so that two samples can be tested simultaneously and compared. The chamber may contain sound absorbing material to eliminate any background noises. Attachment means may also be provided to hold the sample to the holding means. The means for revolving may further comprise a motor attached to a belt which is then attached to a pulley and bearings and causes the shaft to revolve first in one direction and then in the other. Alternatively, the belt may move continuously in one direction causing the shaft to revolve in only one direction. Testing procedures are also provided.

A crumple sound is hereby defined as the noise generated by the sample fabric when it rotates so as to flex or twist. A swish sound is hereby defined as the noise generated by a sample fabric when it is rubbed against another fabric. Fabric is herein defined as a single layer of material or a laminate of two or more layers of material. Materials include natural and synthetic, wovens and nonwovens. Finally, sound and noise are used synonomously herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic front view of the test apparatus without enclosure for testing the crumple sound. The holding means for this apparatus includes a revolving part and a stationary part.

Figure 2 is a schematic front view of the test apparatus without enclosure for testing the swish sound. The holding means for this apparatus includes only a revolving part.

Figure 2a is a schematic cut-away close up perspective view of a test sample undergoing a noise test for the swishing sound

Figure 3 is a schematic front view of the test apparatus for one sample without the enclosure for testing the crumpling sound.

Figure 4 is a front view of a two chamber test apparatus.

Figure 4a is a side view of a test apparatus.

DETAILED DESCRIPTION OF THE INVENTION

An apparatus and method for testing noise generated by fabrics are provided. The apparatus is particularly useful in testing noise characterized as a swishing sound and a crumpling sound as defined above. The apparatus however is suitable for testing other noises generated by fabrics as well. The apparatus and test procedures are suitable for testing a wide range of materials. Here again, fabrics of particular interest include laminates of waterproof and breathable materials having durable face fabrics such as those used in the hunting and sporting industry.

The invention is best understood by reference to the accompanying drawings. Figure 1 is a front cutaway view of the acoustical apparatus 1 which includes holding means 3 which holds the sample fabric to be tested. Figure 1 shows an apparatus that contains holding means for two samples to be tested simultaneously and compared. Figure 3 is a front cutaway view of an

apparatus that provides for only one holding means so that only one sample is tested at a time.

In Figure 1, the holding means 3 for crumple testing include two sets of hollow cylinders that are filled with conventional acoustical material that is used to absorb noise. Each set of cylinders contains one revolving cylinder or holding means 3a and a stationary holding means cylinder 3b separated from each other as shown in Figure 3. The stationary cylinder 3b of Figures 1 and 3 is attached to a wall 4. The test sample 7 is positioned between the ends of the two cylinders and held in place by a fixing means 5. In Figure 1, the fixing means 5 include rubber bands that hold the fabric taut around the perimeter of the end regions of the cylinders. Alternative fixing means including loops and hooks such as Velcro a hooks and fasteners, snaps, adhesives, and other means that hold the fabric to the cylinders may also be used. Figure 1 shows that the fabric ends are attached to the cylinders 3a and 3b while the central area of the test sample is free to twist as the revolving cylinder 3a moves.

The revolving holding means 3a is attached to the end of a revolving longitudinal shaft 9 as shown in the embodiment of Figure 1. The shaft 9 is in turn connected to bearings 11 and a pulley 13. The bearings 11 are supported on stands 15 so as to maintain stability of the apparatus particularly when in operation. The pulley 13 is connected to a belt 17 which is in turn connected to a gearbox 19 and a DC motor 22. The motor 22 and gearbox 19 operate to drive the belt 17 which in turn causes the shaft 9 to revolve around its horizontal axis. The revolution of the shaft 9 in turn causes the revolving cylinder 3a to turn. Sensors 16 are mounted within the sound insulated chamber near the revolving holding means 3a. The sensors 16 track the revolution of the revolving holding means by following a target 16a found on the revolving holding means and as the revolving holding means 3a rotates 180°, a relay is triggered so that the motor 22 reverses direction and causes the revolving means 3a to turn back 180°.

The fabric 7, held in place by the revolving means (cylinder) 3a at one end and stationary means 3b (cylinder) at the other end, is twisted first in one direction as the shaft revolves 180°, causing it to crumple and generate a crumpling noise. As the shaft 9 changes direction to revolve 180° in a counter direction, the fabric 7 is likewise retwisted causing it again to crumple and generate a crumpling noise.

The crumpling noise is detected by a sound detection device 21. Suitable sound detection devices include microphones, and sound level meters. A preferred microphone 21 includes a half inch omni directional

precision microphone commercially available from ACO Pacific Inc. of Belmont, California.

The holding means 3 (cylinders 3a and 3b) are enclosed within housing or enclosure 25 that contains at least one sound insulated chamber 23 as shown in Figure 4 (front view) and Figure 4a (side view). The microphones 21 are also located within the sound insulated chamber 23 so as to monitor the noise generated during the test cycle. When two samples are tested simultaneously, the housing 25 is divided into two sound insulated chambers 23 in which each chamber contains the holding means 3, test sample 5 and each is equipped with a sound detection device 21. All other parts of the testing apparatus are located outside of the sound insulated chamber or chambers. This ensures that the noise levels detected are those only of the fabric 7 being tested. Noise generated from the bearings, pulley, and motor are minimized and quantified. Thus, they do not interfere with the noise generated from the fabric sample. Two samples may be tested simultaneously without interference from the other with the individual sound insulated chambers.

In operation, the sample fabric 7 is attached to the holding means 3 (stationary and revolving cylinders) by fixing means 5 (rubber bands) all located within the sound insulated chamber 23. The dc motor 22 causes the belt to move which in turn causes the pulley and shaft to revolve about the shaft's longitudinal axis. This in turn causes the revolving cylinder 3a to also revolve. As the cylinder revolves 180°, proximity sensors detect such movement and cause motor to reverse direction. As the cylinder moves, the fabric twists first in one direction and then as the cylinder reverses direction, the fabric likewise twists in the other direction. Any noise herein defined as crumpling noise, generated by the fabric during this twisting phenomenon is detected by the sound detection device and recorded.

Tests for the swishing sound are performed in an apparatus slightly modified from that described above and is best understood by reference to Figures 2 and 2a. Here again, the apparatus shows a two-stage testing apparatus to test two samples simultaneously but is also suitable to test only one sample.

The apparatus 1 to test for the swishing sound contains an additional feature namely a stand 31 which holds a sample 33 of the same or different material 7 that is undergoing a test. As shown in Figure 2a, the fabric sample 7 for this test is wrapped in total around one of the holding means (the revolving holding means 3a) which revolves 360°. As the cylinder revolves so

does the fabric sample 7. Since the fabric 7 is attached in total to the revolving holding means 3a, the stationary holding means 3b is not needed for this test procedure. Once again, the fabric sample 7 is held in place on the revolving holding means by fixing means 5 such as rubber bands. The stand 31 with draped sample 33 are positioned to be adjacent to the revolving cylinder 3a and fabric 7 so as to cause direct contact between the draped fabric 33 and fabric sample 7. As the cylinder 3a and fabric 7 revolve as shown in Figure 2a, the sample 7 and draped fabric 33 rub against each other and cause a swishing sound. This sound is detected by the sound detection device 21 and analyzed.

All noise including crumpling sound as well as swishing sound are analyzed by conventional and commercially available equipment. A preferred analyzer is Audio Precision's System One software and equipment commercially available from Audio Precision, Inc. of Beaverton, Oregon. A plot of sound level (in decibels) may be plotted against sound frequency. If two sample fabrics are tested simultaneously, the results of the two samples may be compared.

EXAMPLE CRUMPLE NOISE TEST

The apparatus for the crumple noise test included a housing containing two sound insulated chambers. Each chamber contained holding means in the form of hollow polyvinyl chloride (PVC) tubes having diameters of three inches. The interiors of all tubes were filled with one inch acoustical convoluted foam of Industrial Noise Control, Inc. of Addison, Illinois. One tube from each chamber was attached to a revolving longitudinal shaft that extended from the sound insulated chambers. The other tube in each chamber was stationary. The distance between the revolving tube and stationary tube in each chamber was approximately 8 inches. The revolving tube turned half a revolution in about 20 seconds.

Each sample fabric (10" by 16") as identified below was first stapled together at its top and bottom edges to form a cylinder. The fabric cylinder was then mounted between stationary and revolving tubes with approximately 1" margin of sample on each tube and 8" clearance between the tubes in one of the sound insulated chambers. The sample was held in place on the tubes by rubber bands so that the sample would twist when the revolving tube would turn but would not separate from either tube.

A half inch Omni-directional precision microphone available from ACO

Pacific Inc. of Belmont, California was used to detect the sounds generated from the crumpling. The sounds were then analyzed by Audio Precision System One software and equipment available from Audio Precision Inc. of Beaverton, Oregon.

Test results are as follows:

SOUND MEASUREMENTS*

Fabric Laminate Type	Frequency 3kHz	4kHz	10kHz
50/50 Polycotton and GORE-TEX® membrane - (50/50 polycotton is a blend of polyester and cotton)	40.4	37.8	29.7
Acrylic/Cordura and GORE-TEX® membrane - (Acrylic/Cordura is a woven blend of acrylic and high tensile strength nylon)	36.3	33.9	28.1
Hydrofleece and GORE-TEX ® membrane - (Hydrofleece is a 100% polyester fleece)	30	26.6	26.6
Dry Plus and GORE-TEX® membrane - (Dry Plus is a polyester)	34.6	32.4	27.1
Wool and GORE-TEX® membrane	36.5	34.2	28.3
Saddle cloth and GORE-TEX ® membrane - (saddle cloth is 100% polyester)	33.3	30.7	24.3
330D Cordura and GORE-TEX® membrane - (330D Codura is 330 denier texturized high tensile strength nylon)	37.5	35.5	30.9
Barrier Fleece- GORE-TEX® membrane and Barrier Fleece - (Barrier Fleece is a polyester)	26.7	26.7	22.5

*All measurements are in decibels (dB).

While the invention has been disclosed herein in connection with certain embodiments and detailed descriptions, it will be clear to one skilled in the art that modifications or variations of such details can be made without deviating from the gist of the invention, and such modifications or variations are considered to be within the scope of the claims herein below.

WE CLAIM:

1. An acoustical apparatus for testing noise levels generated from fabric comprising:
   (a) a housing having at least one sound insulated chamber;
   (b) at least one set of holding means contained within the sound insulated chamber;
   (c) at least one fabric sample affixed to the holding means;
   (d) means for fixing the fabric sample to the holding means;
   (e) a revolving shaft attached to the revolving means and located outside of the sound insulated chamber;
   (f) a means for revolving the shaft around its longitudinal axis, said means located outside of the housing; and
   (g) at least one noise detection device located within the sound insulated chamber to monitor noise generated from the fabric sample as it is being tested.

2. An acoustical apparatus as described in Claim 1 for testing crumpling noise further comprising a proximity sensor and the holding means further comprises a revolving holding means and a stationary holding means and wherein the proximity sensor is located within the sound insulated chamber, adjacent the revolving holding means and is capable of detecting 180° radial movement of the revolving holding means and wherein the fabric sample has an edge affixed to an end of the revolving holding means located closest to the sample and an opposite fabric edge affixed to an end of the stationary holding means located closest to the fabric sample.

3. An acoustical apparatus as described in Claim 1 for testing swishing noise further comprising a stationary stand located within the soundproof chamber and adjacent the holding means and a draped fabric made of a material selected from the group consisting of the material of the fabric sample, a different single layer material and laminates of the same or different materials, wherein the draped fabric is draped over the stationary stand and is in direct contact with the sample fabric 3 located in total on the holding means and wherein the holding means is a revolving holding means.

4. An acoustical apparatus as described in claim 1 wherein the housing contains two sound insulated chambers, two holding means, two fabric samples, means for fixing the fabric samples to the holding means and

two noise detection devices wherein one holding means, one fabric sample, and one noise detection device are located within one sound insulated chamber and the other holding means, noise detection device and fabric sample are located in the second sound insulated chamber.

5. An acoustical apparatus as described in claim 1 wherein the holding means are hollow cylinders filled with sound insulating material.

6. An acoustical apparatus as described in claim 1 wherein the fixing means are selected from the group consisting of rubber bands, loop and hook fasteners, snaps, and adhesives.

7. An acoustical apparatus as described in claim 1 wherein the means for revolving the shaft further comprise:
   (a) bearings connected to the shaft;
   (b) a pulley connected to the shaft;
   (c) a belt connected to the pulley and;
   (d) a gear box and motor connected to the belt.

8. An acoustical apparatus as described in Claim 2 for testing crumpling noise further comprising two sound insulated chambers wherein each sound insulated chamber contains a revolving holding means and a stationary holding means, a fabric sample, means for fixing the fabric samples to the holding means, a proximity sensor and a noise detection device.

9. An acoustical apparatus as described in claim 3 for testing swishing noise further comprising two sound insulated chambers wherein each sound insulated chamber contains a revolving holding means with fabric sample attached thereto, a noise detection device and a stationary stand located adjacent the revolving holding means and a draped fabric draped over the stationary stand and in direct contact with the fabric sample.

10. A method of measuring a crumpling sound generated from a fabric sample comprising the steps of :
   (a) fixing a fabric sample having two side edges to holding means comprising a revolving holding means and a stationary holding means located within a sound insulated chamber wherein one side edge of the fabric sample is affixed to a stationary holding means and the other side edge is affixed to a revolving holding means;
   (b) rotating the revolving holding means about its longitudinal axis in a direction 180° causing the side edge of the fabric sample attached

to the revolving holding means to rotate and the fabric sample to twist;

(c) rotating the revolving holding means about its longitudinal axis in an opposite direction 180° so as to twist the fabric sample in another direction and cause a crumpling sound, and

(d) measuring the crumpling sound with a noise detection device.

11. A method of measuring a swishing sound generated from a fabric sample comprising the steps of:

(a) fixing a fabric sample to a revolving holding means;

(b) rotating the revolving means 360° so as to revolve the fabric sample;

(c) contacting said fabric sample with a draped fabric so as to cause a swishing sound; and

(d) measuring the swishing sound with a noise detection device.

12. An acoustical apparatus as described in claim 1 wherein the noise detection device is selected from the group consisting of microphones and noise level meters.

13. A method of measuring a crumpling sound as described in Claim 10 wherein the noise detection device is selected from the group consisting of microphones and noise level meters.

14. A method of measuring a swishing sound as described in Claim 11 wherein the noise detection device is selected from the group consisting of microphones and noise level meters.

FIG. 1

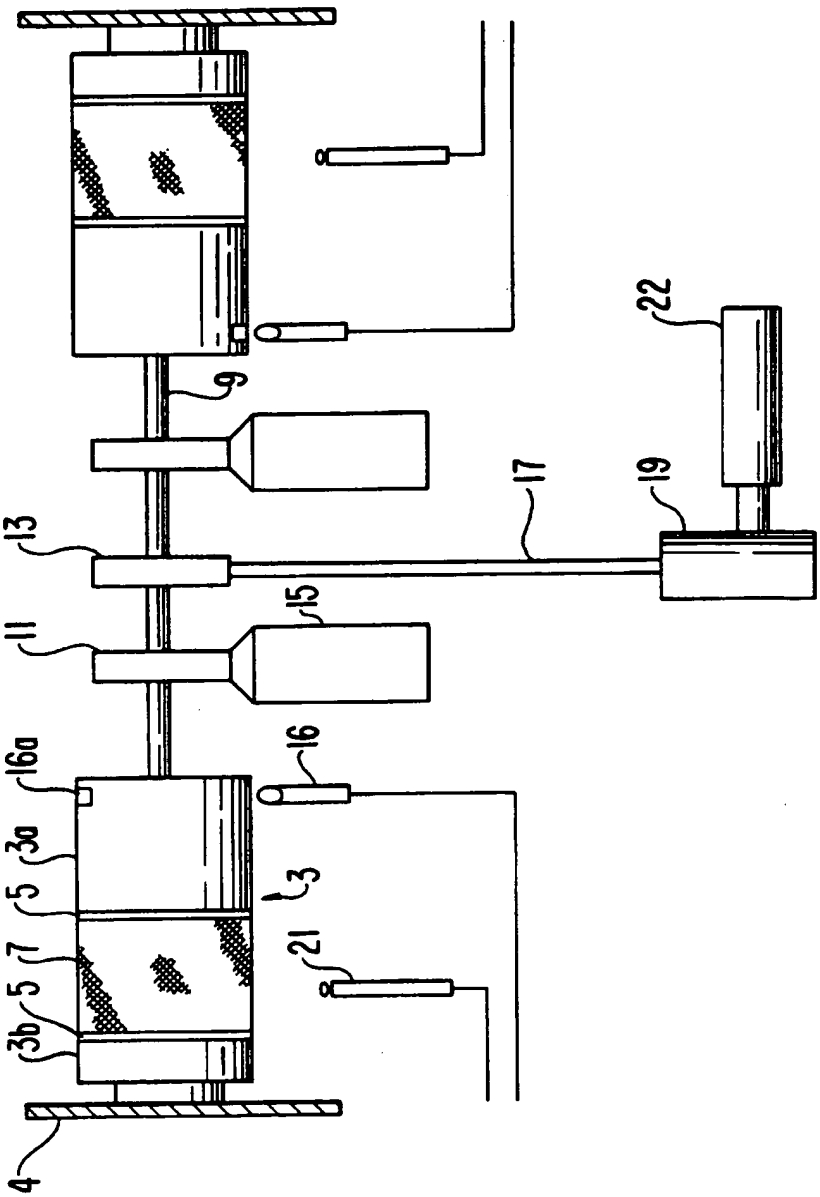


FIG. 2

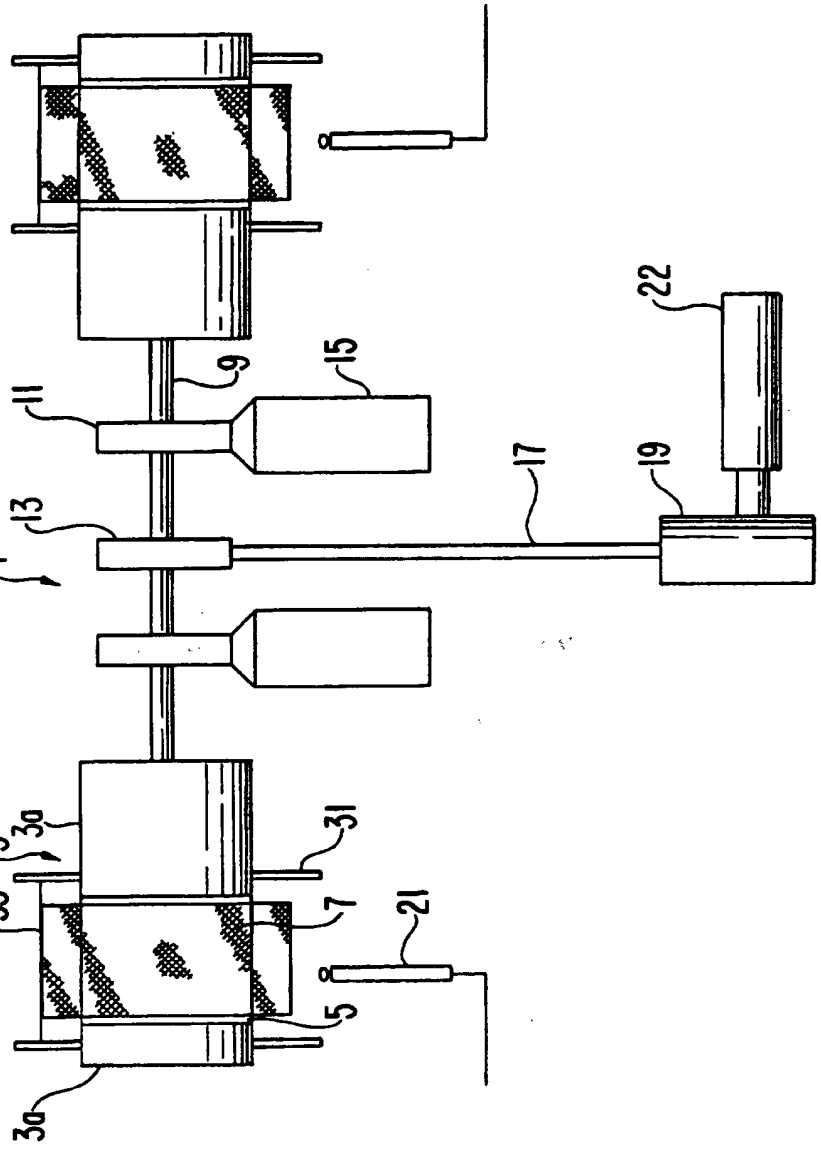


FIG. 2a

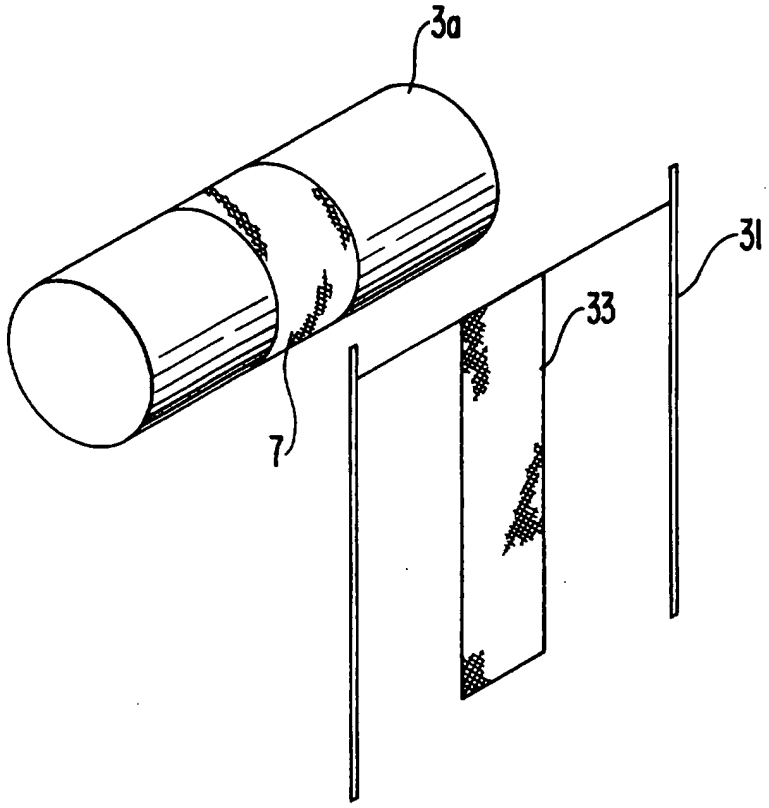


FIG. 3

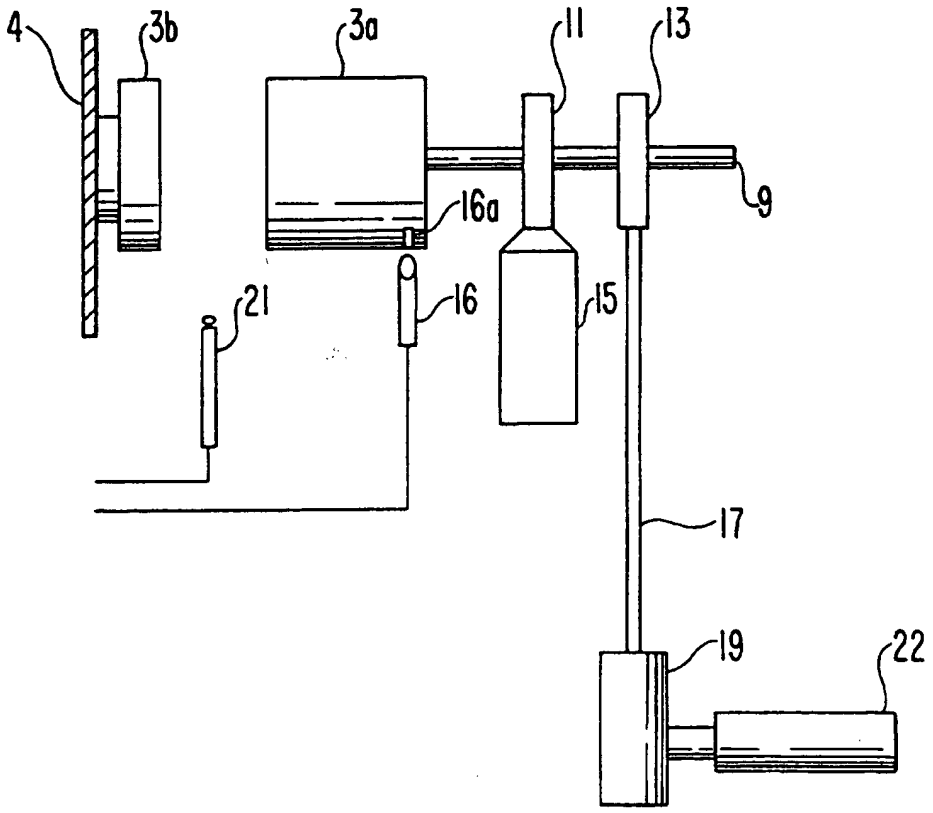


FIG. 4

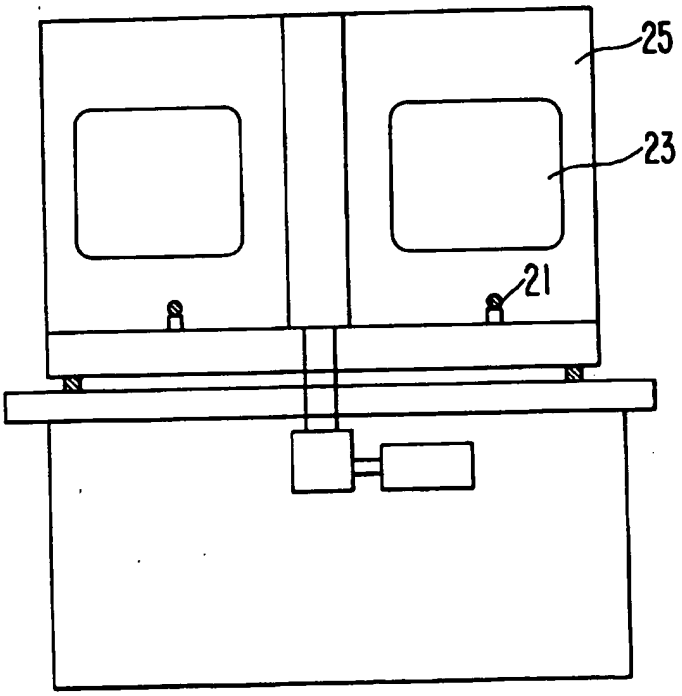
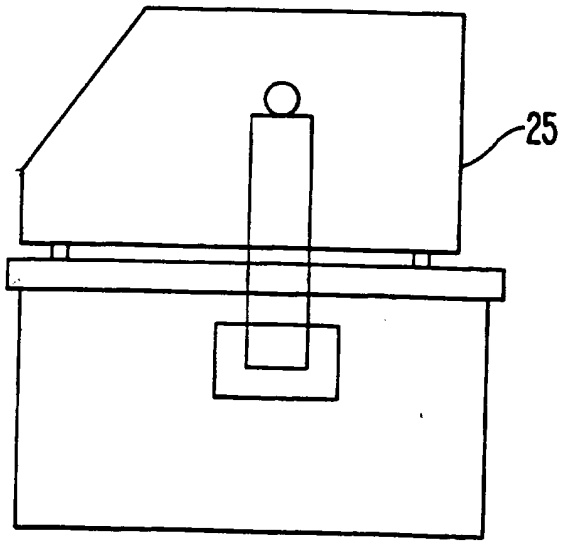


FIG. 4a



INTERNATIONAL SEARCH REPORT

International application No. PCT/US 95/04688

A. CLASSIFICATION OF SUBJECT MATTER

G 01 N 29/14

According to International Patent Classification (IPC) or to both national classification and IPC 6

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G 01 N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 2 922 303 (VENE KLASEN) 26 January 1960 (26.01.60), the whole document.	1
A	--	2-14
A	US, A, 2 752 781 (THORSEN) 03 July 1956 (03.07.56), the whole document.	1-24
A	-- US, A, 3 683 681 (TAYLOR) 15 August 1972 (15.08.72), abstract; fig..	1-24

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Date of the actual completion of the international search

15 September 1995

Date of mailing of the international search report

- 9. 10. 95

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ANHANG

zum internationalen Recherchenbericht über die internationale Patentanmeldung Nr.

ANNEX

to the International Search Report to the International Patent Application No.

ANNEXE

au rapport de recherche international relatif à la demande de brevet international n°

PCT/US 95/04688 SAE 108158

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US A 2922303		keine - none - rien	
US A 2752781		keine - none - rien	
US A 3683681	15-08-72	keine - none - rien	